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ABSTRACT

General development, structure, and uses of a computerized impact projection model, the North Dakota Regional Environmental Assessment Program (REAP) Economic-Demographic Assessment Model, were studied not only to describe a model developed to meet informational needs of local decision makers (especially in a rural area undergoing development), but also to assess elements essential to its development. The REAP model was designed to provide projections of economic, demographic, and fiscal effects of development at state, regional, county, and municipal levels for a 15-county area in western North Dakota where energy impacts were expected to be most important. The model includes variables such as business activity, personal income, employment, population by age and sex, school enrollments, housing requirements, public sector costs and revenues, and net fiscal balance. During 10 months in 1977, 45 different entities used the model for various aspects of planning and decision making. In general, the model was assessed as widely adaptable. Its development process points out factors essential to modelling efforts: models must address real informational needs, take advantage of local research expertise, be multidisciplinary, and be developed in an atmosphere of support from both state and university with a close working partnership between model developers and local data users. (RS)

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Social and Economic Effects of Large-Scale Energy Development In Rural Areas: An Assessment Model

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Social and Economic Effects of Large-Scale Energy Development In Rural Areas: An Assessment Model

INTRODUCTION

The effects of industrialization and resource developments on rural areas are receiving increasing attention and producing an ever expanding body of literature (Summers et al., 1976). One of the most apparent emphases in this literature is the need for local areas to carefully plan for the effects of such developments. Without such planning, communities may either refrain from actions until the impacts become apparent, which may lead to serious boom-town related problems, or over develop in anticipation of population increases and economic growth that may not materialize. It is evident, then, that local area planning is absolutely essential.

For many local areas, especially those in low-density rural areas, however, neither the financial nor the necessary personnel resources are available for such planning. In response to these needs, a variety of federal and state programs have been created and a growing number of manuals and handbooks are appearing aimed at assisting local planners and decision makers (Bronder et al., 1977; Markusen, 1977; Rapp, 1976; HUD, 1976; Wendell Associates, 1976).

Although such general works serve to inform local planners and decision makers about many of the likely problems they may encounter as a result of industrial impacts and inform them of available programs from which they may seek assistance, they do little to answer the direct needs of local decision makers concerning the impacts that they may expect in their specific localities. Thus questions such as--how much business activity a development will create for a given location, how many people will move to a given area, and what effect such changes will have on the schools, medical, police, and other services in a given city--cannot be addressed by such general works. For most local decision makers, however, these specific questions are the ones for which answers are essential.

Local decision makers not only want specific answers, they also want timely ones. Too often, despite the growing number of impact assessments (CEQ, 1977) and the widespread preparation of manuals and books explaining impact assessment processes (Finsterbusch and Wolf, 1977; Abt, 1975; Chalmers and Anderson, 1977), such assessments are often difficult to understand and too outdated to meet local planning needs. The frequency of changes in development dimensions, such as changes in facility size, location, and other factors, often negate the validity of the assumptions on which the formal impact assessment of a project may have been based. As a result, many impact statements tend to be outdated before they are published and the differences between the effects they predict and those that may occur as a result of altered project structures may be impossible for

local decision makers to discern.

As a result of such problems, local decision makers and planners have increasingly demanded impact assessments and impact assessment methodologies that provide local area projections for a variety of socioeconomic factors under a variety of possible sets of development scenarios and that do so with only a limited time delay in the production of such projections.

One form of response to those needs in many areas of the United States has been the development of computerized projection models (Chalmers and Anderson, 1977; Cluett et al., 1977; Hertsgaard et al., 1978; Ford, 1976; Obermiller, 1975; Reeve et al., 1976; Anderson et al., 1974). Though different in structure and level of geographic specificity (Saki, 1977; Stinson and O'Hare, 1977), they all attempt to provide a mechanism that offers rapid responses to pragmatic planning questions. The success of these attempts in actually meeting planning needs, however, appears to depend upon a number of factors, including not only the models' basic structures but also on the mode of their development and the degree to which local inputs have entered into their actual development process.

In this paper the general development, structure, and uses of one such computerized impact projection model, the North Dakota Regional Environmental Assessment Program Economic-Demographic Assessment Model, are described. The intent of the paper is both to describe some of the elements of this type of model and to describe basic elements in their development process. The nature of these development processes, we believe, may be as important as many of the aspects of the methodological design in insuring the utility of such a model. Our purpose, then, is both to describe one example of a growing number of computerized impact assessment models and to assess the essential elements of the processes involved in the development of such a model.

Specifically we shall discuss:

1. The socioeconomic and organizational context in which the model's development occurred
2. The research context of the model's development
3. The structure of the model
4. The types of uses that have been made of the model
5. The adaptability and transferability of the model
6. The elements that appear to be necessary for the successful completion of such a model's development.

In the discussion of each of these issues, of course, it

should be apparent that although we suggest that many of the processes may be generally applicable, our experiences tend to be limited to the western part of the United States and to energy related community impacts. Despite these limitations, we believe that our brief discussion[1] may raise issues that are highly applicable to general issues of model development.

1. SOCIOECONOMIC AND ORGANIZATIONAL CONTEXT

The impetus for the development of the REAP model lay in conditions similar to those occurring in many areas of the western United States. The energy crisis and oil embargo had led to an increasing interest in the energy resources of the West.[2] The development of these resources, which include over 50 percent of the nation's coal reserves and over 67 percent of the strippable reserves, nearly all of the nation's oil shale and uranium deposits, and many of the potential geothermal power sites (FEA, 1976), was clearly essential if the nation's energy needs were to be met.

At the same time, however, such developments within the western context were likely to have large and potentially disruptive impacts on western areas. In most rural areas in the West, long periods of historical population decline due to increased mechanization of agriculture have led to low levels of diversity in rural economies, relatively underdeveloped service infrastructures, and very low population bases. These conditions are likely to cause impacts, that would be of little signigicance in more populous areas, to be problematic for western rural areas.

For example, one of the major resource areas of the Northern Great Plains is the Fort Union coal development area. In 1970 this area included only eight cities over 9,000 people, while a single Lurgi process coal gasification plant, several of which are proposed for the area, may mean an influx of 3,000 construction workers for a three-five year period and 1,000 operational workers for the life of the plant. Such a project, with the additional employment created in the trade and service sectors, may mean that the area will gain between 10,000 and

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[1] Although the discussion of the model's development and structure are presented only briefly here; more extensive descriptions of both the development process and the model structure are available from several sources (North Dakota Regional Environmental Assessment Program, 1976; Hertsgaard et al., 1978; Leistritz and Murdock, 1977a; Leistritz and Murdock, 1977b).

[2] The western states are defined for purposes of this paper as including the states of Arizona, Idaho, Colorado, Montana, Kansas, Nebraska, Nevada, New Mexico, North Dakota, South Dakota, Utah, Wyoming, Oklahoma, and Texas.

20,000 persons during the construction period and between 5,000 and 10,000 persons during the operation of the plant (Northern Great Plains Resources Program, 1974). Thus, although energy developments were seen by many residents in the West as potential sources of needed economic growth, there were also many questions raised about their likely impacts.

Among these questions were "How much economic growth and population increase will these developments mean for specific areas in the West?", "What levels of new employment will be created by the developments?", "How many of the newly created jobs will be available for local persons?", "How many inmigrating workers will be required and where will they choose to live?", "How many dependents will such workers bring with them and what will their characteristics be?", "How many new school, police, fire, medical, and social service facilities and personnel will be needed in local areas?", "How will increased populations and business activity affect public revenues and expenditures?", "How will these factors affect the way of life, life styles, community patterns, and relationships in western areas?". In sum, the apparency of such developments and awareness of their possible effects led to a high level of public concern.

In North Dakota the uncertainty of the answers to such questions, the initiation of several coal related developments, and the occurence of several of the problems noted earlier, such as a lack of local planning information and the production of numerous questionnable and largely irrelevant impact assessments, led to the demand for a statewide program to assist state and local areas in preparing for energy related impacts. Thus in 1975 the North Dakota legislature created the North Dakota Regional Environmental Assessment Program (REAP). Its purpose was to establish and carry on research "in regard to North Dakota's resources and areas of governmental activity or responsibility for the purpose of assisting in the development of new laws, policies, and governmental actions and providing facts and information to the citizens of the state." (Johnson, 1977) It was to serve directly under the control of a legislative committee composed of legislative leaders, university representatives, state agency representatives, and citizens at large and was initially structured to include a staff director and two associate directors, one each in the physical and social sciences, to monitor sponsored research contracts.

After its inception, the program conducted extensive users' meetings with state and local officials and members of the public to discern their informational needs. These needs were, in turn, formulated into research requests and led to numerous research, data base compilation, and modelling efforts. These user groups serve a continuing function, providing ongoing assessments of the utility of sponsored projects.

Among the most frequent needs expressed by the user groups was the need for information on the economic, demographic, and

fiscal impacts of energy developments on the state and local areas within the state.

In recognition of the need for knowledge regarding these factors, REAP initiated two contracts in March of 1976 for the development and computerization of an integrated economic, demographic, and fiscal impact projection model. Model development was contracted to a team of social scientists consisting of Drs. Thor Hertsgaard and Steve Murdock of North Dakota State University, and Drs. Mark Henry and Richard Ludtke of the University of North Dakota, with Dr. Hertsgaard serving as principal investigator of the social science effort. Mr. Norman Toman of North Dakota State University served as the major development specialist in the design of the fiscal-impact component. Computerization and implementation of the model was contracted to Arthur D. Little, Inc., with Mr. Donald Senechal serving as principal investigator, assisted by D. Lebovici, K. Wiig, and A. Czerwinski. Dr. F. Larry Leistritz, Associate Director of REAP, served as the project monitoring official for REAP and also was involved in conceptual design, implementation, and validation of the model.

The model became operational in the fall of 1976 and provides projections of economic, demographic, and fiscal effects of developments at the state, regional, county, and municipal level for a 15 county area in western North Dakota where energy impacts are expected to be most significant (Hertsgaard et al., 1978). An expanded version of the model that includes the entire state and nonenergy as well as energy related developments has recently been completed (Hertsgaard et al., forthcoming).

In examining these contextual factors of the model's development, we believe the apparent and impending need for planning information and the state's subsequent active financial and political support of the project were directly responsible not only for the project's completion, but also for the model's widespread use.

2. RESEARCH CONTEXT

The research context of the model's development should also be described. In particular, two elements appear to have been instrumental in the model's development: the extent of the previous research conducted by persons on the development team concerning economic modelling and energy related impacts in the state and the direct, close working relationships maintanined between the development team and state data users.

Attempts to model the North Dakota economy had been underway for some time by the development team's senior researchers. Under the direction of Dr. Thor Hertsgaard of the Department of Agricultural Economics at North Dakota State University, data had been collected from business firms and selected households

and governmental units in western North Dakota, an input-output model for the state had been developed (Sand, 1966; Bartch, 1966) and its validity assessed (Senechal, 1971). This model had, in turn, been used extensively to examine a number of applied problems (Hertsgaard and Leistritz, 1973; Leistritz and Dunn, 1971; Helgeson and Zink, 1973). Thus by the time the development of the model began, over ten years of experience in modelling the state's economy had been accumulated.

In addition, in the direct analysis of energy impacts considerable previous experience also had been obtained. Beginning in 1972, analysis of the likely effects of energy developments on the state's tax structure, level of economic activity, and service structure had begun (Hertsgaard and Leistritz, 1973; Leistritz and Hertsgaard, 1973). Studies of the regional, as well as statewide, impacts of large scale developments had been completed through the Northern Great Plains Resources Program (Dalsted et al., 1974; Leholm et al., 1974) and several assessments of the impacts of specific energy projects had been completed (Dalsted et al., 1976; Toman et al., 1976; Coon et al., 1976).

In the analysis of social and demographic changes considerable work had also been completed. This work included assessments of the likely social impacts of various energy developments (Schriner et al., 1976a, 1976b) and of the present and likely future trends in population (Ludtke and Blair, 1974; Ludtke, 1976; Murdock and Ostenson, 1976).

In sum, then, the model's development took place within a context in which an extensive amount of previous research regarding both energy impacts and the economic, demographic, and fiscal effects of such developments already had been completed. This research experience sensitized the development team to both the demands and the potential pitfalls of such a modelling effort.

The second element of significance within the research context was the close working relationships that were maintained between the development team and various state users. The relatively small number of state officials and university researchers in the state led to a high level of interdependence. State officials freely provided access to data sets that were essential to the model's development and served as willing reviewers of preliminary model results. The development team, in turn, provided preliminary model outputs, with appropriate qualifications, to state officials for various uses. This pattern of mutual interdependence was clearly significant in the model's development.

The research context, then, was one in which a large amount of in-state research experience and expertise, together with a highly interdependent process of interaction between model developers and data users, was brought to bear on a particular re-

search need. These elements, we believe, also affected completion of the modelling effort.

3. MODEL STRUCTURE

The economic-demographic projection model provides baseline projections and single or multiple-project impact projections for a 15 county area in western North Dakota. Outputs are available at the regional, county, and municipal levels and include such variables as business activity, personal income, employment by type, population by age and sex, school enrollments by age, housing requirements by type, public sector costs and revenues by type and net fiscal balance.

The model consists of five basic components or submodels. These are:

1. An Economic Input-Output Module.
2. A Cohort-Survival Demographic Module.
3. An Economic-Demographic Interface Module.
4. A Residential Allocation Module.
5. A Fiscal Impact Module.

The Input-Output Module is used to estimate gross business volume by economic sector for a specified level of final demands. Employment requirements by sector and development phase are then derived from the estimates of gross business volume. The Demographic Module provides projections of population by age and sex and an estimate of the available labor force. The Interface Component links the projections of required employment from the Input-Output Module with the projections of available labor force from the Demographic Module to determine the level of employment needs that can be met by the indigenous population and those that must be met by the in-migration of new workers. The Residential Allocation Module estimates the settlement patterns of new workers and their families and the Fiscal-Impact Module provides projections of the expected costs and revenues resulting from the associated economic and demographic changes. These factors operate differentially at the regional, county and municipal level. A generalized flow diagram of the model is presented in Figure 1. A more detailed description of each component follows.

The Input-Output Module

Input-output analysis is a technique for tabulating and describing the linkages or interdependencies between various industrial groups within an economy. The economy considered

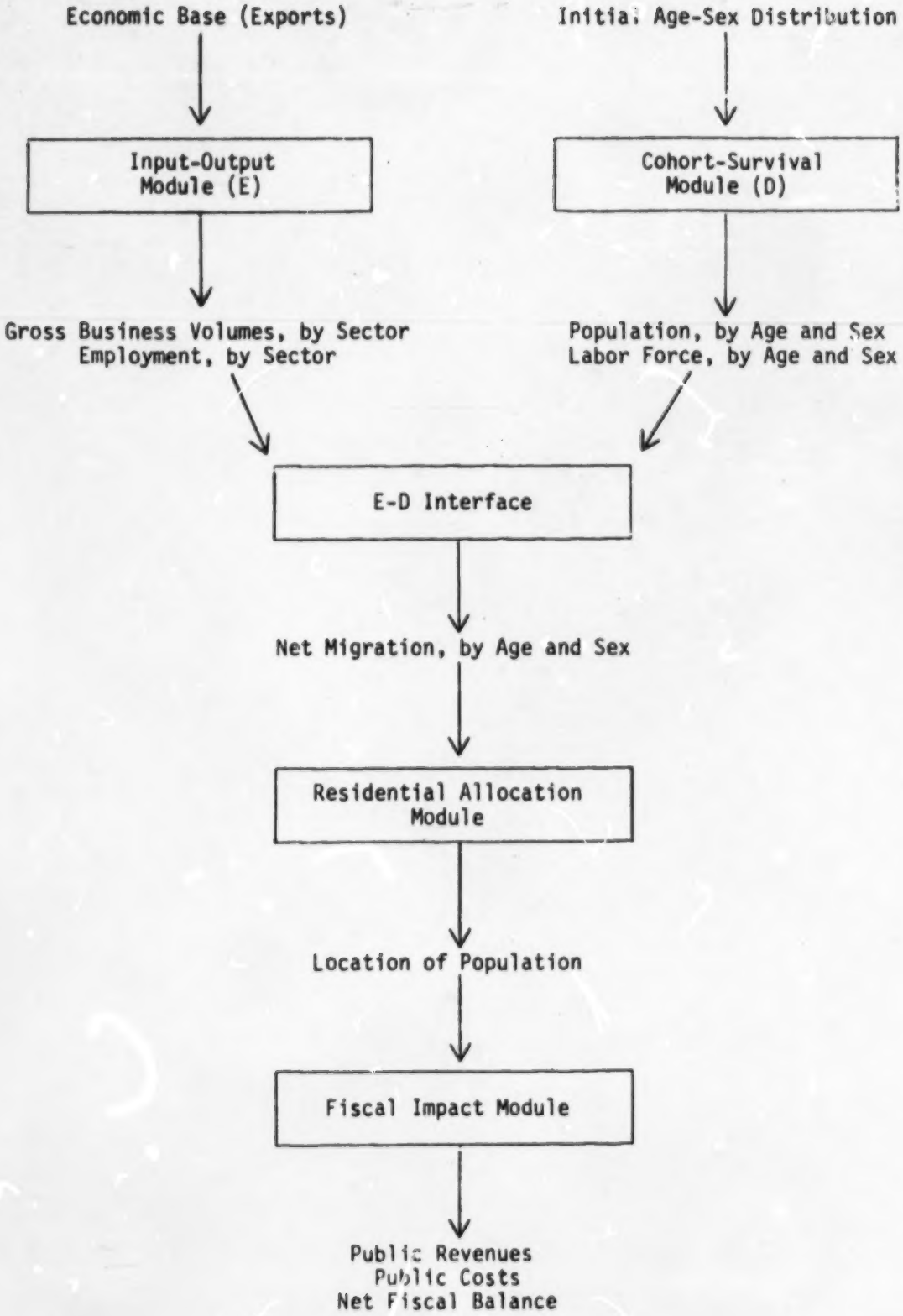

Figure 1. Data and Output Flows of Economic-Demographic Model.

may be the national economy or (in the present example) an economy as small as that of a multi-county area served by one of the state's major retail trade centers. Input-output analysis, as used in this model, assumes that economic activity in a region is dependent upon the basic industries that exist in that region, referred to as its economic base. The economic base is largely a region's export base, i.e., those industries (or "basic" sectors) that earn income from outside the area. (These activities in western North Dakota consist of livestock and crop production, manufacturing, mining, tourism in the area, and federal government outlays in the area.) The remaining economic activities are the trade and service sectors, which exist to provide the inputs required by other sectors in the area.

The input-output model employed is similar to conventional models,[3] except in three respects. First, the model is closed with respect to households. In other words, households are included in the model as a producing and a consuming sector. Second, the total gross business volume of trade sectors was used (both for expenditures and receipts in the transactions table) rather than value added by those sectors. This procedure results in larger activity levels for those sectors than would be obtained by conventional techniques, but this is offset by correspondingly larger levels of expenditures outside the region by those sectors for goods purchased for resale. The advantage of this procedure is that the results of the analysis are expressed in terms of gross business volumes, rather than value added, of the respective sectors. This procedure appears to be more meaningful to most users. The third difference from conventional models is that all elements in the column of interdependence coefficients for the local government sector were assigned values of zero, except for a one in the main diagonal. This was intended to reflect the fact that expenditures of local units of government are determined by the budgeting process of those units, rather than endogenously within the economic system.

The input-output model employed was derived from primary data collected by personal interviews from firms and households in southwestern North Dakota. The model was developed by Sand (1966) and Bartch (1968) and the coefficients were subsequently tested for validity by Senechal (1971).

The conceptual basis for an input-output model is that production by any sector requires the use of production inputs, such as materials, equipment, fuel, services, labor, etc., by that sector. Some of these inputs will be obtained from outside the region (imported), but many will be produced by and purchased from other sectors in the area economy. If so, these other sectors will require their own inputs from still other sectors,

[3] A nontechnical discussion of input-output analysis may be found in Harmstrom and Lund (1967). More detailed treatments are found in Leontief (1966), and Chenery and Clark (1959).

and so on. These additional rounds of input requirements generated by production of the direct input requirements (of the initial sector) are known as the indirect requirements.

The total of the direct and indirect input requirements of each sector in an economy is measured by a set of coefficients known as input-output interdependence coefficients. Multiplication of the interdependence coefficients by the sales of the basic sectors (income received from outside the region or sales for final demand) yields estimates of the gross business volumes of each of the sectors in the region. The resulting product for the household sector is personal income received from the respective business sectors in the form of wages and salaries, profits, rents, and interest income of individuals. The estimates of gross business volume for other sectors are used to estimate employment in those sectors.

The procedure for translating gross business volume in the respective sectors to employment involves dividing gross business volume in each sector by gross business volume per worker in that sector.[4] This procedure was employed to estimate trends in baseline employment on the basis of time series projections of the final demand vectors and projections of gross business volume per employee in the respective sectors. A similar procedure was used to estimate economic impacts of construction and operation of energy plants on the basis of estimated local expenditures for construction and operation of these plants. The end result was, for the economic baseline and for any set of development projects, an estimate of total required employment. This estimate of total required employment is later used in the E-D interface component of the model.

The Cohort-Survival Demographic Module

The second component of the model is the Cohort-Survival Demographic Component. This mode of population projection was selected because it has been generally accepted as among the most accurate projection techniques and provides outputs at a significantly greater level of detail than most other methods.[5] In addition, its methodology and data base had been extensively developed for the state of North Dakota.[6]

The cohort-survival method of population projections

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[4] Gross business volume per worker was computed from historic employment data for the years since 1958 for each of the sectors.

[5] For a discussion of alternative population projection techniques and their relative capabilities, see Barclay (1958) and Shryock and Siegal (1973).

[6] See Murdock and Ostenson (1976).

consists of the application of a set of birthrates, migration rates and survival rates to a set of baseline population data for a projected period in order to determine the population at the end of that period. In general, it produces projected population derived from the basic population equation:

$$P_{t_2} = P_{t_1} + B - D + M \qquad (1)$$

Where: P_{t_2} = Population at a given future year, t_2

P_{t_1} = Population at a preceding base year, t_1

B = Births between t_1 and t_2

D = Deaths between t_1 and t_2

M = Net migration between t_1 and t_2

Rather than utilizing total population figures, this method employs a set of age-sex cohorts (persons of the same sex born during the same period of time) and sets of mortality, migration, and fertility rates specific to each of these cohorts. These cohort rates for the projected period are applied to the population in each cohort to estimate the future population of an area. For any given geographical area and projection period the procedure may be seen as relating to equation (1) as follows:

$$P_{t_2} = \Sigma P_{c_i,t_2} \qquad (2)$$

Where: P_{t_2} = Population at a given future year, t_2

$\Sigma P_{c_i,t_2}$ = Sum of population in all cohorts at a given future year, t_2

and

$$P_{c_i,t_2} = P_{c_i,t_1} + P_{c_i}B_{t_1,t_2} - P_{c_i}D_{t_1,t_2} + P_{c_i}M_{t_1,t_2}$$

Where: P_{c_i,t_2} = Population of cohort i at a future time, t_2

P_{c_i,t_1} = Population of cohort i in the preceding base year, t_1

$P_{c_i B t_1,t_2}$ = Births to cohort i between the base year, t_1, and future year, t_2

$P_{c_i D t_1,t_2}$ = Survival in cohort i between the base year, t_1, and future year, t_2

$P_{c_i M t_1,t_2}$ = Net migration in cohort i between the base year, t_1, and future year, t_2

In the model, 15 five-year age-sex cohorts were used (males and females 0-4, 5-9, etc.) for each sex. The initial population in each cohort was derived from the 1970 Census of Population. Although single year cohorts would have been preferable for many of the computational aspects of the model, the computational requirements imposed by using this number of cohorts and corresponding mortality, migration, and fertility rates (over 75 for each sex) initially prevented the use of such a procedure. (Single year cohorts are employed in E-D Model, Version 2, which is currently being developed.) Rates for the processes of migration[7] (for those older than 65), mortality[8] and fertility[9] were based on historic data. In projecting future patterns, migration rates for persons less than 65 years old were determined through the interface procedure described below. Future patterns for survival rates and fertility rates were assumed to follow national trends over time with a fertility level of 2.1 births per adult female being used as a default value.[10] This fertility level is one which would result in a replacement level of births and reflects current levels of fertility in North Dakota.

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[7] Age-sex specific migration rates for North Dakota counties for 1960-1970 were taken from Bowles, Beale, and Lee (1975).

[8] For mortality, survival rates were computed from life tables from Ludtke and Blair (1974).

[9] Age-specific fertility rates were computed from births by age of mother for 1972, 1973, and 1974. These data were obtained from the Division of Health Statistics, North Dakota State Department of Health.

[10] The fertility rates are computed for each female cohort from 10-45+ years of age. The sum of these age-specific rates for all cohorts is the total fertility rate. In the present model, the user is allowed to choose a total fertility rate ranging from 1.8 to 2.5 for the projection period. These rates are used in computation of age specific rates that would result in the user selected average number of births (during her lifetime) per female in a population. The rates resulting in a 2.1 level of completed fertility are utilized in the model if the user does not specify some other permissible value.

Given projections of population by age and sex, the number of workers available locally is obtained from the Cohort-Survival Module by application of labor force participation rates to each age-sex cohort. The participation rates employed in this module are the maximum values that are likely to occur and are based on historic rates for the more urbanized counties of North Dakota.

The Economic-Demographic Interface Module

The Economic-Demographic (E-D) Interface Component is the linkage between the Economic Input-Output Module and the Demographic Cohort-Survival Module. It consists of a set of labor force requirements (from the Input-Output Module), a set of labor force availability functions (from the Cohort-Survival Module), a procedure for comparing required and available labor forces and a procedure for determining the demographic effects of in- or out-migration. The procedures differ somewhat depending on whether baseline or impact projections are being made.

The basic approach is that the required employment levels (as determined by the Input-Output Module) and the available workers (as determined by the Cohort-Survival Module) are compared to determine whether the indigenous population can provide the necessary labor force or whether in-migration will be necessary. Comparison of required employment and available workers is accomplished through job assignment functions that match workers from four population subgroups with jobs of four types. The job types are jobs in energy project construction, jobs in energy facility operation, jobs indirectly created by energy project activity and jobs associated with baseline economic activity. The four population groups are:

1. Construction workers and their families;
2. Operation workers and their families;
3. Indirect workers and their families;
4. Indigenous population.

The indigenous population (group 4) is the only population present in any county or community prior to the start of a project, while population groups 1-3 are in-migrated as additional work forces are required for projects and indirect activities. These population groups and the indigenous population are out-migrated later if available jobs are reduced.

The methodology of defining participation rates for potential jobholders for different job sectors (construction, operation, indirect, and indigenous) from different population groups is formulated through work force participation matrices.

This allows representation of the fact that different individuals from a family may be available to hold jobs in different sectors. The primary worker is available for holding a job in the job sector associated with his population group. Associated with this worker is an average family unit with members in all age-sex cohorts. The primary worker's employment is assumed to govern the in- or outmigration of the family unit. Other members of the family, however, may be available for work in different job sectors, once in the community. In particular, the availability of potential jobholders for the sectors is shown in Table 1 in terms of (1) participation rates (shown for four of the 15 age cohorts) and (2) the number of potential jobholders for four sample populations with 100 males and 100 females for each age cohort.

The philosophy of the job assignment rules is that in-migrated populations are not eligible for taking indigenous jobs, but indigenous populations have priority to take any job (although it is postulated that a specified fraction of each job class must be filled by in-migrating workers) until the available pool of potential jobholders from each allowable population is exhausted. The sequence and priority of attaining a job for potential jobholders from different population groups are indicated in Table 2. Jobs in a sector are filled in the sequences indicated with in- or out-migration of the population associated with the principal jobholder of that sector so as to balance the employment in the sector. Example: If, for 1,000 indirect jobs, 10 jobs are unfilled after the following allocation has taken place:

1. 120 jobs (12 percent) are filled by required in-migration of indirect workers;

2. 60 jobs filled from indigenous population;

3. 400 jobs filled from operating worker population;

4. 180 jobs filled from construction worker population;

5. 230 jobs filled from indirect workers already present;

then 10 indirect workers and their families must be in-migrated to fill all 1,000 jobs.

In Table 1, for convenience of accounting for the potential jobholders, the work force participation for each job sector includes the participation for the preceedingly allocated sector; i.e., for the construction worker population, the potential jobholders for operation jobs, includes the potential jobholders for the construction jobs. Hence, the potential jobholders for operations work are equal to 40 persons (i.e., the 1,177 [from Table 1] less the 1,137 primary workers [number of potential jobholders] who have already been assigned to construction work).

TABLE 1. POTENTIAL JOBHOLDERS FOR FOUR AGE COHORTS FOR CONSTRUCTION, OPERATIONS, INDIRECT, AND INDIGENOUS JOBS AND POPULATIONS

	POPULATION			CONSTRUCTION JOBS			OPERATIONS JOBS			INDIRECT JOBS			BASELINE JOBS		
	Age Cohort	Male	Female	Participation Male	Participation Female	Potential Jobholders	Participation Male	Participation Female	Potential Jobholders	Participation Male	Participation Female	Potential Jobholders	Participation Male	Participation Female	Potential Jobholders
Population associated with construction work force	15-19	100	100	0.6	0.07	67	0.6	0.07	67	0.5	0.3	80	0	0	0
	20-24	100	100	1.0	0.07	107	1.0	0.11	111	1.0	0.2	120	0	0	0
	25-29	100	100	1.0	0.07	107	1.0	0.11	111	1.0	0.2	120	0	0	0
	30-34	100	100	1.0	0.07	107	1.0	0.11	111	1.0	0.2	120	0	0	0
	Total	1,500	1,500		Total	1,137*		Total	1,177		Total	1,280		Total	0
Population associated with operation work force	15-19	100	100	0	0	0	0.5	0.2	70	0.6	0.4	100	0	0	0
	20-24	100	100	0	0	0	1.0	0.17	117	1.0	0.4	140	0	0	0
	25-29	100	100	0	0	0	1.0	0.17	117	1.0	0.4	140	0	0	0
	30-34	100	100	0	0	0	1.0	0.17	117	1.0	0.4	140	0	0	0
	Total	1,500	1,500		Total	0		Total	1,240		Total	1,500		Total	0
Population associated with indirect work force	15-19	100	100	0	0	0	0	0	0	0.6	0.5	120	0	0	0
	20-24	100	100	0	0	0	0	0	0	1.0	0.6	160	0	0	0
	25-29	100	100	0	0	0	0	0	0	1.0	0.6	160	0	0	0
	30-34	100	100	0	0	0	0	0	0	1.0	0.6	160	0	0	0
	Total	1,500	1,500		Total	0		Total	0		Total	1,720		Total	0
Indigenous population	15-19	100	100	0.2	0	20	0.2	0.05	25	0.6	0.6	120	0.6	0.6	120
	20-24	100	100	0.6	0.07	67	0.6	0.1	70	1.0	0.6	160	1.0	0.6	160
	25-29	100	100	0.6	0.07	67	0.6	0.1	70	1.0	0.6	160	1.0	0.6	160
	30-34	100	100	0.6	0.07	67	0.6	0.1	70	1.0	0.6	160	1.0	0.6	160
	Total	1,500	1,500		Total	690		Total	725		Total	1,720		Total	1,720

*Total potential jobholders are cumulated over all 15 age cohorts.

TABLE 2

SEQUENCE AND PRIORITIES FOR JOBFILLING
BY POTENTIAL JOBHOLDERS

Job Sector	Potential Jobholder from Population Group
Baseline Jobs	1. Indigenous Population*
Construction Jobs	1. Construction workers population in specified fraction of jobs
	2. Indigenous population
	3. Construction workers (in or outmigration to balance)
Operating Jobs	1. Operating worker population in specified fraction of jobs
	2. Indigenous population
	3. Construction worker's associated population
	4. Operating worker population (in or outmigration to balance)
Indirect Jobs	1. Indirect workers population in specified fraction of jobs
	2. Indigenous population
	3. Operating worker population
	4. Construction worker population
	5. Indirect population (in or outmigration to balance)

*Outmigrate indigenous population after the employment for all job sectors including indirect jobs are satisfied.

The characteristics (marital status, age of spouse, number of children, age of children, and labor force participation rates of dependents) of inmigrating and outmigrating workers were assumed to be similar to those indicated by available data for such workers. Data have been collected for inmigrating construction and operating workers through surveys conducted at North Dakota coal mines and power plants.[11] Census data profiles of previous outmigrants provide the basis for estimating characteristics of future outmigrants from the area (i.e., an outmigrating primary worker is assumed to have an associated average family unit the characteristics of which are based on Census profiles).

The number of in-migrating workers and their dependents is allocated to the respective municipalities in the proportions determined by the residential allocation model (described in the next section).

The Residential Allocation Module

The Residential Allocation Component of the model is used to estimate the probable location patterns of in-migrating workers and their dependents. These allocations are made at the municipal level using a gravity model. The gravity model was chosen as the basis for residential allocation because similar models have been used extensively (and with suitable accuracy) to explain commuting patterns and patterns of population distribution, as well as other phenomena.[12] Use of the gravity model involves the basic assumptions that inmigrants will tend to settle in population centers in direct proportion to the population of those centers, but that the number of inmigrants moving to a city will be inversely related to the distance between that city and the employment site. Finally, the model assumes that qualitative differences between possible settlement locations will affect settlement choices. In symbolic form these assumptions may be stated as follows for each work site:

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[11] Data collection procedures are described in Leholm et al. (1975); Leholm et al. (1976a); and Mountain West Research, 1975.

[12] For a review of the historical development of the gravity concept, see Carrothers (1956). Discussions of the use of gravity models in regional economic analysis are provided by Isard et al. (1972); and Richardson (1969).

$$M = \frac{\left[\frac{P_i}{D_i^a}\right] W_i}{\sum_{i=1}^{n} \left[\frac{P_i}{D_i^a}\right] W_i} \quad (3)$$

Where: M_i = Fraction of total in-migrants locating in city i

P_i = Population of city i

D_i^a = Distance between city i and the work site, raised to the power a

W_i = The relative qualitative attraction of city i

The user may specify values for the power (a) to which distance is raised and the value of the community attraction index (W_i) for any city. Separate gravity model allocations are made for each type of worker. Standard values for the exponent parameters (a) were estimated using data on settlement-commuting patterns of construction workers at electric generating plant construction sites in North Dakota, Montana and Wyoming and similar data for permanent (operating) workers at coal mines and power plants in North Dakota, South Dakota, Montana and Wyoming.[13] The value of the exponent parameter (a) for indirect workers was estimated through analysis of changes in employment patterns in western North Dakota communities that have previously experienced coal development. The estimated exponent values are 1.5 for construction workers, 2.9 for operating workers and 1.6 for project-related indirect workers, and these values are used in the residential allocation process unless the user specifies alternative values. This results in a smaller proportion of construction workers being allocated to municipalities near the plant site than is the case for operating workers. A slightly greater proportion of indirect workers is allocated to nearby cities than are construction workers.[14]

The community attraction index (W_i) allows the user to

[13] Data collection procedures are described in Leholm et al. (1976a), for construction workers and Leholm et al. (1975) for operating workers. Statistical procedures for establishing the exponent parameters are described by Wieland (1977).

[14] For construction and operation workers, the gravity model allocates population to communities as a factor of commuting distance to the work site. Indirect workers are also allocated to communities as a factor of distance to the site of a project; however, indirect workers are assumed to both reside and work in the community to which they have been allocated.

give weights to particular cities if he believes they will attract fewer or more people than that determined by their population and distance from the employment sites. Values of 1.0 (meaning no weights are assigned) are assumed for all cities unless otherwise specified by the user. User choice of a number larger than 1.0 will result in more inmigrants being assigned to that city and choice of a value less than one will reduce that city's share. User specification of W_i values other than 1.0 generally has been based on specific local information regarding relative availability of housing and key public services.

The Fiscal Impact Module

The final component of the Economic-Demographic Model is the Fiscal Impact Module. This component, utilizing the expected settlement patterns from the gravity model and subsequent population changes determined for each area by the economic and demographic models, determines the expected public sector costs and revenues associated with such changes. The model provides for the estimation of both state and local costs and revenues.

In each case the model works through a three-step procedure which involves:

1. Computation of expected increased public revenues,
2. Computation of expected increased public costs,
3. Computation of net difference between increased costs and revenues referred to as the net fiscal balance.

At the state level, the revenue sources included in the model are:

1. The sales and use tax,
2. Personal income tax,
3. Corporate income tax,
4. State share of coal severance tax,
5. State share of coal conversion tax,
6. Business and corporate privilege tax,
7. Highway taxes,
8. Cigarette-tobacco and liquor-beer taxes,
9. County equalization levies.

At the local level, revenue sources included in the model are:

1. Ad valorem property taxes,
2. User fees (e.g., for sewer, water, and solid waste disposal service),
3. Special assessments (e.g., for street improvements),
4. Transfer payments, including school foundation program payments, federal revenue sharing payments, highway fund payments, and cigarette and tobacco tax payments,
5. Local share of coal severance tax,
6. Local share of coal conversion tax.

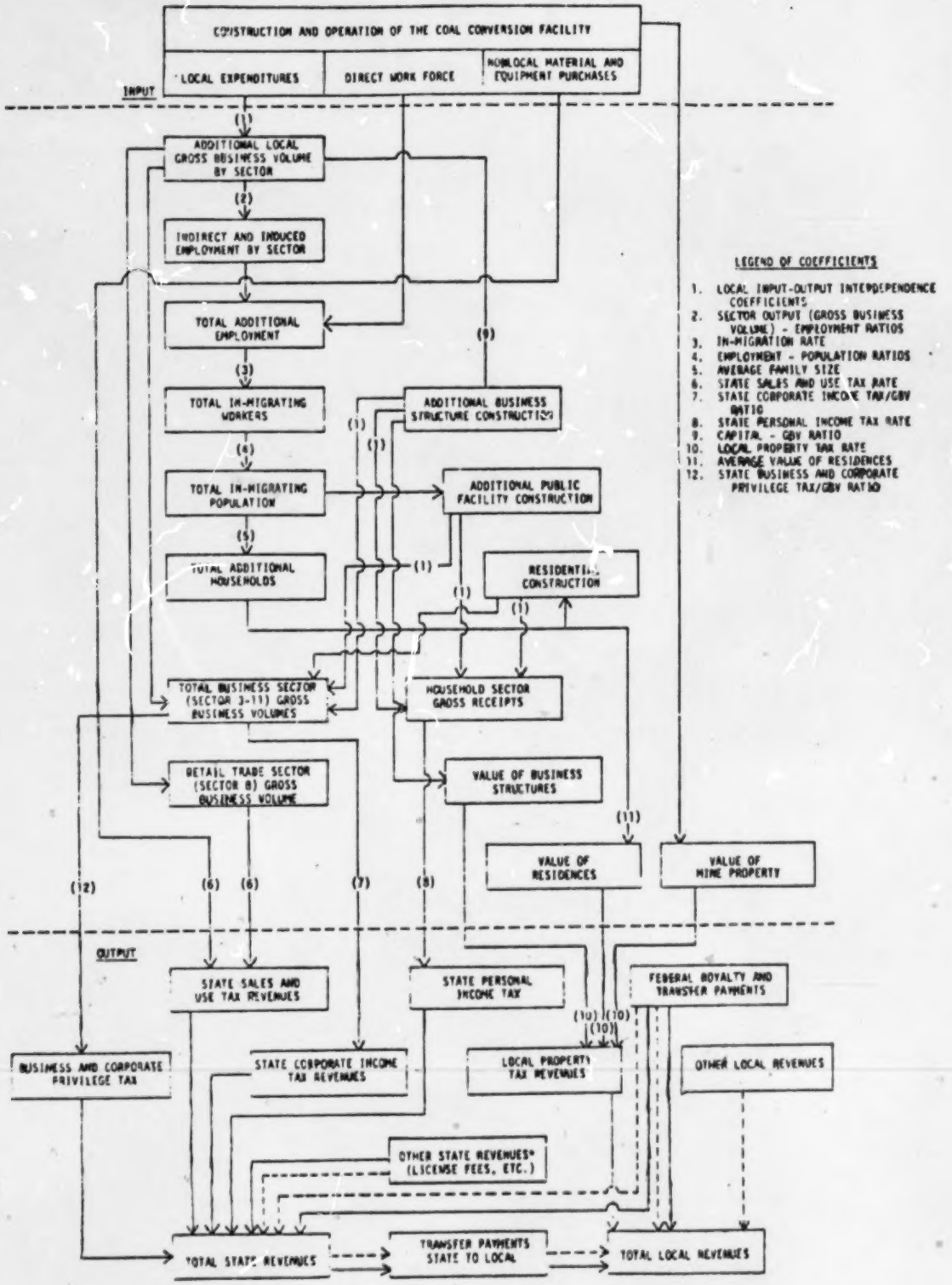
At the state level, the costs included are:

1. Per capita costs of general government functions,
2. Highway maintenance costs,
3. Highway construction costs,
4. School foundation program payments.

At the local level, the costs included are:

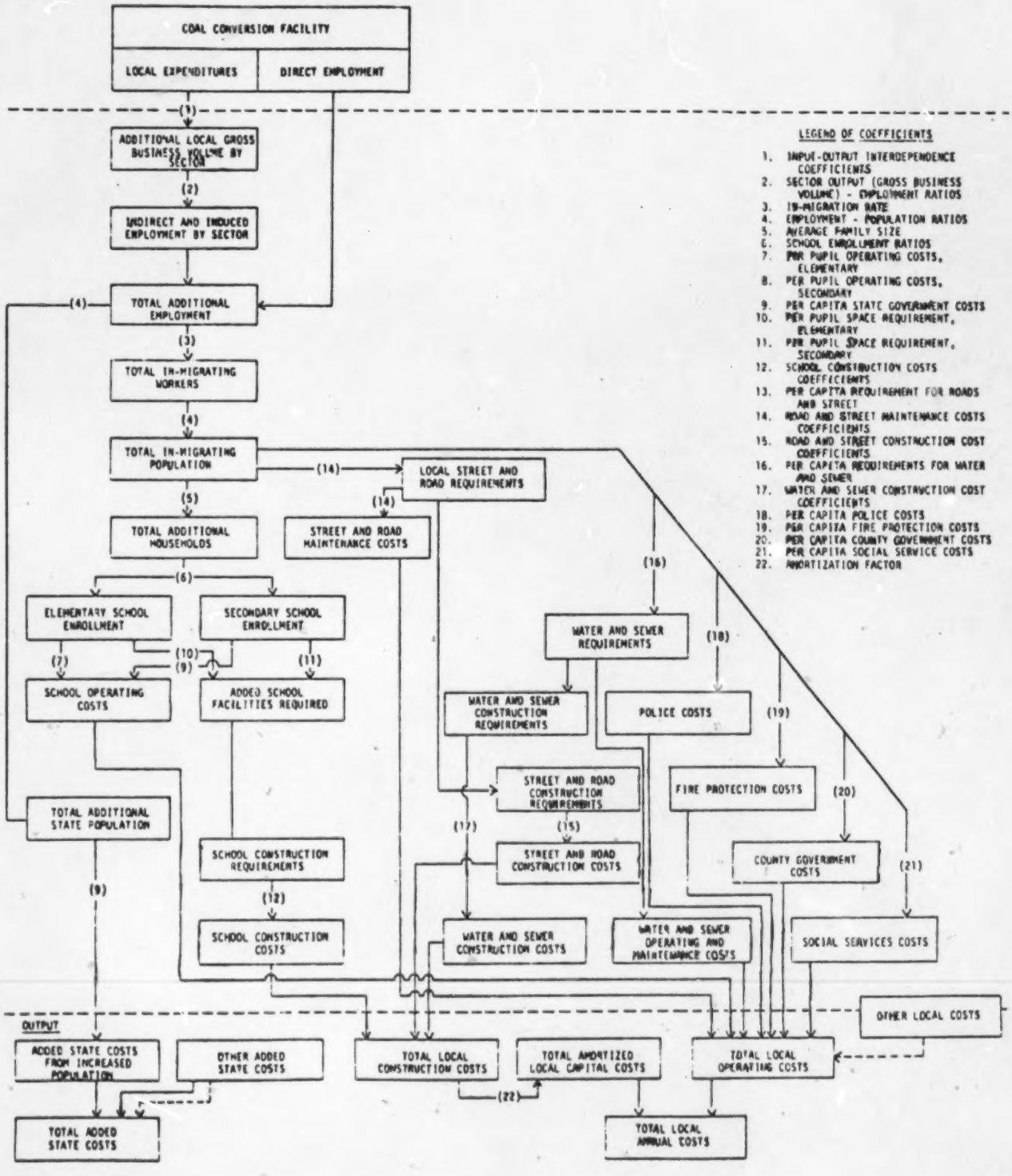
1. School construction and operating costs,
2. Street construction and operating costs,
3. Water and sewer system construction costs,
4. Law enforcement operating costs,
5. Fire protection costs,
6. Social service costs,
7. Local general government costs.

The interrelationships involved in calculation of project-related revenues are shown in Figure 2 and those involved for project-related costs are shown in Figure 3. Changes in state sales and use tax revenues are estimated on the basis of historic relationships between sales tax collections and the gross receipts of the retail trade sector. Changes in state personal income tax collections are estimated on the basis of the historic relationship between personal income tax collections and total personal income. The same procedure is followed in estimating increased corporate income tax and business and corporate privilege tax collections, except that collections



*INCLUDES COAL SEVERANCE TAX AND TAXATION OF CONVERSION FACILITIES.
DASHED LINES (---) REPRESENT REVENUE FLOWS NOT ESTIMATED BUT INCLUDED FOR CONCEPTUAL COMPLETENESS.

FIGURE 2. Flow Chart of Revenue Estimation for a Coal Conversion Facility, North Dakota.



DASHED LINES (---) REPRESENT COST FLOWS NOT ESTIMATED BUT INCLUDED FOR CONCEPTUAL COMPLETENESS.

FIGURE 3. Flow Chart of Cost Estimation for a Coal Conversion Facility, North Dakota.

are based on total gross business volume of all business sectors. Increases in collections of the various highway taxes and liquor and tobacco taxes are estimated on a per capita basis.

Severance tax collections are based on a per ton rate for all coal mined in North Dakota with receipts allocated according to the prevailing statutory formula. The coal conversion tax applies to coal-fired electric generating plants, coal gasification plants, and other coal conversion facilities. The conversion taxes are in lieu of all ad valorem taxes except those on the land occupied by the plants and receipts from this tax are divided between the state general fund and the county in which the facility is located. The county's portion is further subdivided between the county general fund, school districts and municipalities.

The estimate of added property tax revenue is obtained by applying the prevailing statewide average property tax rate to the estimated taxable value of additional business structures and residences resulting from the industrial development and associated population growth. The estimated average investment cost for houses, apartments, and business structures is used as the basis for estimating taxable value for those structures and the taxable value for mobile homes is estimated using one-half the purchase price.

State school foundation program payments associated with increased enrollments are based on payments per pupil. Federal revenue sharing payments are estimated on a per capita basis. Increased user fees are estimated on the basis of present rates per household, while special assessment revenues are based on amortized capital investments for streets, water and sewer and solid waste disposal.

This module also accounts for reductions in tax revenues resulting from decreased agricultural production. The potential reduction in agricultural production is estimated on the basis of the acreage to be used for the plant site; the acreage to be mined; and the acreage expected to be used for residential, transportation and related uses. The reduction in acreage is translated into a reduction in sales to final demand by the agricultural sectors. Hence, the estimated changes in employment, income, and state and local tax revenues are net changes (i.e., increases resulting from industrial expansion less decreases resulting from reduced agricultural production).

Estimates of capital costs for new facilities are based primarily on recent engineering data, while operation and maintenance cost estimates are based primarily on cross-sectional regression analysis of a sample of county and city budget data from counties and cities in western North Dakota. The counties and cities included in the sample covered the range of potential populations of the communities likely to be affected by the new industrial developments.

To permit comparison of net fiscal balances for the years in which costs and revenues are realized, all cost and revenue components are computed on the basis of the most current data available and adjusted to the 1975 price level. Then, those components that are subject to price level changes are inflated at a rate selected by the user (the default rate is 7 percent) through the life of the development. Increased costs are subtracted from increased revenues to obtain an estimate of the net fiscal balance by year for the state and local units of government.

User Procedures: Scenario Development and Reporting

The software for the computerized E-D Model was programmed in APL, a language well suited to carrying out complex calculations in an interactive mode via a computer terminal. The program was designed to make the model-user dialogue simple for users with little or no background in modeling or computer use. To date, the limited capability of the state computer center for supporting timesharing users has required that all requests for E-D projections be directed to the REAP office. However, it is anticipated that in the future a number of users will utilize their own terminals to access the model from remote locations.

The model was constructed to allow maximum user interaction in the specification of development scenarios and assumptions regarding key variables, such as timing of development, settlement patterns, and birthrates. In addition, the user is able to specify those reports which he wishes printed. Given the large number of reports available to the user and the time required to print these reports via terminal, this is an important feature.

User specification of development scenarios, assumptions and reporting is accomplished through a question and answer session between the user and the model. For instance, when setting the birthrate assumptions for the model, the terminal will print "DEFAULT BIRTHRATE IS 2.1 BIRTHS PER FEMALE. OK?" Other such choices by the user are provided for in the program. If the user is willing to accept the standard value stored in the computer, he types "YES" and the computations will proceed using that value.

Scenario Specification

The variables whose values the user can alter include:

1. Length of projection period - Projections begin in 1975 and can be run through 1999. However, if the user is concerned only with the period from 1975 to 1985, the specification of a scenario with projec-

tions only to 1985 will reduce computer computation time requirements.

2. Number of projects, sites and construction start dates - The model includes a library file of project data describing key parameters (i.e., direct employment, and local expenditures) of the various coal extraction and conversion projects proposed for development in North Dakota. The user has the option of selecting any or all of these projects for inclusion in a given scenario. The default values for project site and start date represent the most recent information provided by the developing companies. The user can use these projects in various combinations reflecting his evaluation of the likelihood that each project will actually be developed. In addition, by adjusting starting dates for various projects, he can examine the effect of project timing on the cummulative impacts experienced by various communities. Finally, by changing the default sites of various projects, the user can obtain tentative answers to the question, "What would be the effects if a project like project X were developed near my community?"

3. Gravity powers and community attraction index values for the residential allocation model.

4. Birthrate.

5. Rate of inflation.

6. Rates for major taxes - sales and use tax, coal conversion tax and severance tax.

Because human errors are always possible, the model is programmed to accept only changes in variables within a reasonable range. In the case of birthrates, for example, a value can be chosen between 1.8 and 2.5 average births per adult female. If the user's specified value is outside this range, an error message is typed and the user is asked to respecify the value of that variable.

It should be noted that most users do not wish to alter the values of variables, such as birthrates, gravity model coefficients, etc. The default values for these variables are based upon the best available data for North Dakota.[15] However, if the user has new data or wishes to test the effect of chang-

[15]The term "DEFAULT" is a conventional term used in computer programming to indicate no action on the part of the user.

ing these variables, he has this capability.

Reporting Options

The model provides projections for a 15-county area of western North Dakota and for individual counties and municipalities within this area. The projections are presented in a series of standard reports. The standard reports are:

1. Scenario Specification Report: This report is printed at the beginning of each E-D reporting sequence. It includes a listing of the values used for all user-accessible variables.

2. Regional Economic Activity Report: The following items are indicated for the 15-county region for the years specified by the user:

   Project Related

      Business Activity (gross business volumes of all business sectors - sectors 3-11)

      Personal Income (gross business volume of sector 12)

   Baseline

      Business Activity

      Personal Income

   Total

      Business Activity

         Amount

         Change (from the previous year shown)

         Percent Change (from the previous year shown)

      Personal Income

         Amount

         Change (from the previous year shown)

         Percent Change (from the previous year shown)

Per Capita

Amount

Change (from the previous year shown)

Percent Change (from the previous year shown)

At the beginning of each report, the user has the opportunity to specify the years for which he wishes to have the output printed. Thus, users can receive reports showing the results for each year from 1975 to 1999 or for any subset of those years.

3. Regional Summary: The following information is reported for the 15-county region for the years specified by the user:

Population

Total

Change (from the previous year shown)

Percent Change (from the previous year shown)

Employment

Project Related

Construction

Operating

Indirect

Baseline

Total

Change (from the previous year shown)

Percent Change (from the previous year shown)

4. County Summary: This report indicates, for counties and years specified by the user, the following:

Population

Total

Change (from the previous year shown)

Percent Change (from the previous year shown)

Employment

Project Related

Construction

Operating

Indirect

Baseline

Total

Change (from the previous year shown)

Percent Change (from the previous year shown)

5. Municipalities Report: This report contains identical information, for the municipalities and years specified by the user, as that contained in the county summary report. Employment for each city includes farm employment for the surrounding area.

6. Population by Age and Sex Report: This report indicates, for counties and years specified by the user, the population by sex for each of 15 age cohorts (0-4, 5-9, . . . 65-69, 70+).

7. School Enrollment Report - Impact Students: This report indicates, for municipalities and years specified by the user, the number of primary (grades K-6) and secondary (grades 7-12) students associated with in-migrating project related workers (i.e., construction, operating, and indirect workers).

8. Housing Report - Impact Housing: This report indicates, for municipalities and years selected by the user, the number of additional housing units that will be required by the in-migrating project related workers. Four types of housing are shown in this report: single family houses, apartments, mobile homes and ad hoc housing. (Ad hoc housing includes motel and hotel rooms, and sleeping rooms and is important only for temporary construction workers.)

   A County Housing Report also is available. This report simply totals the various classes of housing by year for all municipalities in a given county.

9. Fiscal Impact Reports: These reports indicate (for

the units of government and years selected by the user) the changes in public revenues and costs for those years associated with the projects in the scenario selected by the user. Therefore, to obtain the true net balance for the state, the user should list all 15 counties as counties of interest. The reports, for the units of government and years specified by the user, contain the following information:

a. Project Induced State Budget Impact Report (state level fiscal impacts associated with projects in the counties selected by the user):

State Income

- Sales and Use Tax
- Personal Income Tax
- Corporate Income Tax
- Corporate Privilege Tax
- Highway Tax
- Cigarette-Tobacco-Liquor-Beer Tax
- Equalization Tax
- Coal Conversion Tax
- Severance Tax
- Total Income
- Net Balance (total income minus total expenditures, also shown in the "State Expenditures" section of this report)

State Expenditures

- Education Transfers (to local government)
- Highway Fund (transfers)
- Cigarette and Tobacco (transfers)
- Conversion Tax (transfers)
- Severance Tax (transfers)
- Highway Construction
- General Government Functions
- Total Expenditures
- Net Balance (total income minus total expenditures)

b. County Fiscal Impact Report: This report indicates, for counties and years selected by the user, the following information:

Income

- Share of Local Property Tax
- Federal Revenue Sharing
- Highway Fund (transfers)
- Conversion Tax (transfers)
- Severance Tax (transfers)

Expenditures

Law Enforcement
Social Services
Other Government

Net Fiscal Balance (total income minus total expenditures)

A County Aggregate Fiscal Impact Report also is available. This report totals the income and expenditures by category by year for any combination of counties selected by the user.

c. **Municipality Fiscal Impact Report: This report indicates, for municipalities and years specified, the following:**

Income

Share of Local Property Tax
Education Transfers
Federal Revenue Sharing
Users' Fees
Special Assessments
Highway Fund (transfers)
Cigarette and Tobacco (transfers)
Conversion and Severance Tax (transfers)

Expenditures

Schools
Streets
Police and Fire
City Government
Debt Service

Net Fiscal Impact (total income minus total expenditures)

A Municipality Aggregate Fiscal Impact Report, combining the fiscal reports of user selected municipalities, also is available.

In addition to the standard reports listed above, a great deal of additional information can be obtained from the model. Values of many variables are calculated as intermediate products. The values of these variables can be output, if desired, upon special request to REAP.

Model Validation

The accuracy of the model in estimating key economic and

demographic variables was evaluated through a backcasting process. The accuracy of the Input-Output Module was evaluated by Senechal (1971) and subsequently by Hertsgaard, et al. (1977). In the latter study, final demand vectors were computed for the coal producing area of western North Dakota (state regions 7 and 8) and then were multiplied by the interdependence coefficients to obtain the level of personal income generated by that level of sales to final demand. These estimates of personal income were compared with those reported by the U.S. Department of Commerce for the years 1959, 1963, and 1965-1975 (Table 3). The last column of Table 3 indicates the difference between the estimated and reported values expressed as a percent of the Department of Commerce estimate. This difference is less than 5 percent for 7 of the 13 years and only 2 years have differences of more than 10 percent. The average difference is 5.2 percent for the entire 13-year backcast period.

Similar evaluation was attempted with respect to other key economic and demographic variables. Lack of reported data at the county and subcounty level limited the conclusions that could be drawn (e.g., official population counts for counties and towns normally are available only from the decennial Census of Population). However, special population censuses were completed during the period 1975-77 for some communities near North Dakota coal development sites. Comparison of the census population estimates with population projections from the model indicated that the differences between projected and reported population generally were less than five percent.

4. MODEL USERS AND USES

One of the ways of assessing the utility of a modelling effort such as that we have described is to examine the types of uses it has had. Thus in this section we wish to briefly indicate some of the uses to which the model has been put. During the period January 1 to October 31, 1977, 45 different entities used the model for various aspects of planning and decision making. (A complete listing of these users is included as Appendix A.) The 45 user organizations made 63 different requests for E-D Model projections, which required a total of 179 model runs. Some users of the model have included:

1. The U.S. Bureau of Land Management - In cooperation with the State of North Dakota, the BLM is developing a Regional Environmental Impact Statement for proposed coal development and associated federal coal leasing in western North Dakota. The BLM and state study teams used the E-D Model as their basic source of economic, demographic, and fiscal impact projections for the Regional EIS and for a series of project-specific environmental impact statements.

2. The North Dakota Coal Impact Office - The Coal Impact

Table 3. Comparison of Personal Income Estimated from Input-Output Model and Report by U.S. Department of Commerce, State Regions 7 and 8, 1959-1975.

Year	Estimated by Input-Output Techniques ($1,000)	Reported by Department of Commerce[a] ($1,000)	Percentage Difference
1959	211,861	195,262	8.5
1960	213,667	N/A	-
1961	199,121	N/A	-
1962	263,372	262,882	0.2
1963	274,302	N/A	-
1964	288,647	N/A	-
1965	304,692	323,317	5.8
1966	353,927	338,263	4.6
1967	348,267	346,067	0.6
1968	360,178	355,397	1.3
1969	423,145	412,451	2.6
1970	448,158	431,830	3.8
1971	477,770	469,912	1.7
1972	591,867	560,011	5.7
1973	779,882	736,877	5.8
1974	853,948	734,139	16.3
1975	850,757	764,895	11.2
Average Difference[b]			5.2

[a]As reported by U.S. Department of Commerce, Bureau of Economic Analysis, Regional Economics Information System, Washington, D.C., August 1976.

[b]Computed without respect to sign.

N/A - The U.S. Department of Commerce did not report personal income for these years.

Office has the statutory responsibility for distributing several million dollars annually to aid local governments which are experiencing unusual expenditures as a result of coal development. These impact funds have been used primarily for capital facilities improvement, and the Coal Impact Office has used E-D Model projections as one source of information to assess the need for various facilities.

3. The North Dakota Legislature - During the 1977 Legislative Session, various legislative committees utilized E-D Model projections in the preparation of major revisions in the state's system of coal industry taxation and revenue distribution. The projections indicated that cities and school districts in coal impact areas might incur substantial long-term fiscal deficits; the new legislation resulted in substantial increases in the revenues accruing to these jurisdictions.

4. The North Dakota Public Service Commission - The Public Service Commission has statutory authority for issuing siting permits for energy conversion facilities. The commission has used E-D Model projections as an aid in evaluating a series of permit applications for electric generating and coal gasification plants.

5. The North Dakota State Highway Department - The Highway Department used population and employment projections developed by REAP as the basis for estimating changes in traffic volume by road segment through 1989. The projected changes in traffic volume were used to develop estimates of highway construction needs and associated costs in a seven-county area.

6. A number of counties, cities and school districts have used the model in developing capital budgets and in various other planning activities. For example, the City of Beulah was involved in a capital facilities planning effort. Of most immediate concern was the need to expand the city's sewage treatment facility. The mayor and Planning Commission requested a series of population projections for the city consistent with alternative levels of future energy development. These projections were then used to determine the most appropriate design capacity for the new treatment facility.

7. Private development companies and consulting firms.

The REAP staff's interactions with these users have indicated that users find the following characteristics of the model to be particularly desirable:

(a) Projections incorporate both baseline and impact conditions; thus, population projections for a given county or city indicate the likely future trend without development, as well as the effect of specific developments.

(b) Ability to analyze multiple projects - A number of communities could receive major impacts from several different development projects. The model can show the combined effect of several projects and also can show the changes that would occur if a given project were postponed or developed at a different site.

(c) Geographic specificity - Whereas, projections at the state or substate regional levels are useful; of even greater value to community decisionmakers is the capability for obtaining projections at the county or municipal levels.

(d) Flexibility - The model allows for easy selection of alternative patterns and rates of development.

(e) Quick response - Population and economic projections are now developed in a matter of hours; whereas, previously the community might have been forced to commission a special study requiring months to complete.

5. MODEL ADAPTABILITY AND TRANSFERABILITY

In sparsely populated rural areas where a new energy development can have major impacts, preplanning is of special importance. Preplanning, however, requires estimates and projections of the magnitude, type, and location of these impacts. The Economic-Demographic Model just described was developed to meet the information needs of communities confronted with a particular type of proposed energy development (i.e., coal mines and coal conversion plants). However, a model of this type could be useful in evaluating the community impacts of a wide range of energy developments and other large construction or industrial projects and providing public decisionmakers with useful planning information.

The model should be widely adaptable for two reasons. First, the economic and social impacts associated with the construction and operation of a coal-fired power plant should be very similar in their general nature to those associated with the construction and operation of other facilities of comparable size. The magnitude of impact will differ between projects depending on both project variables (e.g., size and occupational structure of the work force, duration of construction activity, extent of local input purchases) and site

variables (e.g., size, occupational composition and employment status of area work force; capacity of area social service delivery systems; tax structure). However, the model's structure allows for the input of project-specific data for each of these project and site variables. Second, when a proposed energy project or other construction project is of the magnitude which would result in major community impacts, the variables included within the model are quite pervasive. Local officials need estimates of the magnitude, timing and geographic distribution of population changes and attendant service needs to initiate their planning processes, and these needs are similar for any major development.

The approach embodied in the Economic-Demographic Model should be applicable to site- and project-specific projections of the impacts of a variety of energy developments. The basis for the economic impact analysis is a regional input-output model, and similar models have already been used to estimate the impacts of a wide range of proposed energy developments and other major industrial projects. For example, input-output (I-O) techniques have been used to project the impact of a 24,000 MWe nuclear energy center (Isard, et al., 1976), a coal-fired electric generating complex (Adcock, et al., 1975), and a major oil shale development (Auger, et al., 1976).

One prerequisite to use of the input-output technique is development of I-O coefficients for the area of interest. However, such coefficients have been developed for many states and substate areas. If an appropriate I-O table is not available, a table can be prepared using either primary or secondary data sources. While the initial cost of a primary data I-O table is substantial, the multiplicity of uses for the table may well justify the cost. Alternatively, use of secondary data to develop the tables may offer a way to reduce costs without a major sacrifice in accuracy (Boster and Martin, 1972).

If the development of an input-output table from primary or secondary data is deemed infeasible, the economic module of the E-D Model could be redesigned to utilize employment and income multipliers developed by export base or econometric techniques.

The cohort-survival demographic model is applicable to many population forecasting efforts. The basic data source for present population distribution and past trends is the United States Census of Population. Birthrates and survival rates are generally based on Census Bureau projections or state vital statistics data. The most serious problem in demographic projection is usually the development of migration estimates. However, if the cohort-survival model is linked to an economic projection model, estimates of employment-induced migration can be calculated internally. It is necessary, in this case, to make assumptions concerning the characteristics of in-migrating

workers (i.e., age, number of dependents). In some cases, special surveys of the work forces of analogous projects may be useful as a means to estimate these characteristics.

The fiscal impact component of the model also is adaptable (with some modifications to account for institutional differences) to other types of development and should be transferable to other states. Some changes undoubtedly would be needed in the revenue subroutine to account for variations in tax structure between states. Fewer alternations would be needed in the public services and facilities cost subroutine.

The basic outputs of the model, as well as the data entering into its development, provide a wealth of information appropriate for the development of additional modelling efforts aimed at assessing other impacts of a major development change. Thus, the basic output data could be used to assess medical service needs, recreational and social services needs, and environmental effects of new development projects. In sum, the model, although developed in response to information needs created by coal development in rural areas, should be adaptable to the assessment of impacts from a wide range of developments such as manufacturing, build-up of military installations, agricultural processing, irrigation and highway construction in both rural and urban areas.

The latest version of the model which includes the entire state and nonenergy as well as energy developments should also provide a further indication of the utility of the model for projecting nonenergy related impacts. Finally, a major assessment of the transferability of the model will be made during the coming year when an attempt will be made to assess its utility for projecting industrial related impacts in Texas. The greater density of many Texas areas, as well as its more complex economy should provide a good indication of the usefulness of the model's general structure and its adaptability to other settings.

6. NECESSARY FACTORS IN A MODEL'S DEVELOPMENT AND USE

Although the effort noted above has a number of unique elements, we believe the process involved in this effort may point to a number of general factors that should be considered before a modelling effort is undertaken. These factors, then, are ones which we believe are essential in expediting such an effort.

First, among the most essential factors in such a modelling effort is the awareness of the need for the information it can provide and the quick provision of information to meet these needs. Modelling efforts tend to be attractive to university researchers because of the methodological challenge they entail. If such models fail to be addressed to real informational needs, however, they are likely to end up being valuable exercises for the researchers but of little real utility. Thus we would main-

tain that the timing of such efforts must be right such that the needs of decision makers and the expertise of the researcher can be properly meshed. If such efforts are pursued before local decision makers sense the need for the information they can provide or if their development entails such an extensive time frame that the important issues have already been addressed prior to the model's completion, such efforts will not be highly utilized or well received.

Secondly, and closely related to the above factors, is the need for such efforts to involve a close partnership between model developers and local data users. The participation of local data users, such as county extension agents, local and regional planners, and other state and local officials, serves many purposes, including easier access to data bases, correction of model inaccuracies, increased information on local conditions, and an increased likelihood that, since they have been involved in its development, local decision makers will use the model. Such efforts should not proceed without such interdependence.

Thirdly, and also closely related to the previous factors, is the need to take advantage of local research expertise. Although the ease of obtaining packaged systems from outside groups may be attractive, the use of such systems cannot provide the kind of indepth background that is often essential for assessing a model's utility and the validity of its outputs.

Fourthly, such efforts must be truly interdisciplinary not multidisciplinary. Although economists and sociologists will inevitably have different perspectives, our experience would indicate that each will benefit from the work of the other. Too often demographic projections ignore economic realities, especially in rural areas and equally often economic projections ignore the significance of demographic structures. Close interdependencies must be recognized and utilized.

Finally, it is essential that such efforts occur within a supportive atmosphere, both within the state and university setting. Researchers must be assured that such efforts will have both pragmatic and professional rewards and local users must see the actual utility of the product received for meeting state and federal funding and other administrative requirements. To ignore the importance of such structural factors is to insure the failure of such an effort. As with other types of applied efforts, then, there must be an assurance of support.

CONCLUSION

In sum, then, the REAP Economic-Demographic Modelling effort is but one example of an ever growing interest in developing computerized models aimed at meeting the informational needs of local decision makers. We believe it is serving a number of

local needs and that the form of development it utilized may provide a beneficial model. As with any such effort, however, we would suggest that its continued use will provide the best evidence concerning its ultimate value to local decision makers.

APPENDIX A

REAP E-D Model Users

January 1-October 31, 1977

State Government

Executive Branch:

Office of the Adjutant General (North Dakota National Guard)
Coal Impact Office
Public Service Commission
State Water Commission
Highway Department
State Laboratory
State Highway Patrol
Social Service Board
State Department of Health
Department of Public Instruction
State Planning Division
Governor's Office (Office of Energy Coordinator)
State Tax Department
Regional Environmental Impact Statement (a cooperative project of the Bureau of Land Management, U.S. Department of Interior, and the State of North Dakota)

Legislative Branch:

Senate Minority Leader (Senate Chamber)
Senate Majority Leader (Senate Chamber)
North Dakota Legislative Council

Judicial Branch:

State Supreme Court

County Government

Mercer-Oliver County Engineers (Inter-State Engineers, Jamestown)
Mercer County Task Force
Land Use Administrator (Oliver County)
Mercer County Social Service Board
Oliver County Health Services

City and School Officials

Turtle Lake-Mercer School Board
Hazen Public School District #3
Auditor's Office - Killdeer
Social Service Coordinator (Bismarck - Early Childhood Education Program)
Community Development Office - Bismarck
Mandan Planning and Development Office
Underwood Public School District #8
Beulah Mayor
Beulah Planning Commission
Hazen City Planning Office
Mayor's Office - Garrison
Mandan Planning and Development Office

Regional Organizations

Missouri River Basin Commission (Level B Study)
Lewis & Clark 1805 RCD - Mandan
Western Governors' Regional Energy Policy Office
Roosevelt Custer RCD - Dickinson
Old West Regional Commission - Special Project (State Board for Vocational Education)

Institutions of Higher Education

Bismarck Junior College
Department of Agricultural Economics (NDSU - Fargo)
Department of Economics (UND - Grand Forks)

Private Firms

Resource Planning Associates
Meyer Broadcasting Company, Inc.

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